with reference to FIGS. **4**, **5**A, and **5**B, and thus the detailed descriptions thereto is omitted.

[0076] A conditional fluorescent material layer FML may be formed on the substrate **100**, such that the conditional fluorescent material layer FML may cover the preliminary photoresist patterns **132***p* (S**125**). The conditional fluorescent material layer FML may include a material of which fluorescence is activated under an acid condition. That is, for example, the conditional fluorescent material layer FML may include CypHer5E (a pH sensitive dye made by GE Healthcare) or pHrodo® (a pH sensitive dye made by Thermo Fisher Scientific). For example, the conditional fluorescent material layer FML may be formed using a CVD method, a PVD method, or an ALD method.

[0077] The conditional fluorescent material layer FML may include first portions FML**1** covering the preliminary photoresist patterns **132***p*, and second portions FML**2** covering portions of the anti-reflective layer **120**, respectively. The second portions FML**2** may be exposed between the preliminary photoresist patterns **132***p*. The first portions FML**1** may be in contact with the preliminary photoresist patterns **132***p*. Accordingly, the first portions FML**1** may react with the acid included in the preliminary photoresist patterns **132***p*, and thus the fluorescence of the first portions FML**1** may be activated. In other words, the first portions FML**1** may have the fluorescence. The preliminary photoresist patterns **132***p* may be formed on the anti-reflective layer **120** (S**122**). As shown in FIG. **7**, the photoresist patterns **132***p* may be covered with the first portions FML**1**. The photoresist patterns **132***p* and the first portions FML**1**, in combination, may define as the fluorescent photoresist patterns **132** (S**120**). The second portions FML**2** may be in contact with the portions of the anti-reflective layer **120** exposed between the preliminary photoresist patterns **132***p*, and may be spaced apart from the preliminary photoresist patterns **132***p*. As described above, the anti-reflective layer **120** may not have acidity, and thus, fluorescence of the second portions FML**2** may not be activated. In other words, the second portions FML**2** may not have the fluorescence.

[0078] Referring to FIGS. **6**, **7**, and **8**, shapes of the fluorescent photoresist patterns **132** may be observed and/or inspected using a fluorescence microscope (S**130**). Observing and/or inspecting the fluorescent photoresist patterns **132** using the fluorescence microscope may be substantially the same as described with reference to FIGS. **1**, **2**B, and **3**.

[0079] FIG. **9** is a flow chart illustrating a method for observing and/or inspecting a photoresist pattern, according to some example embodiments of inventive concepts. FIGS. **10**A and **10**B are cross-sectional views illustrating the method for observing and/or inspecting a photoresist pattern of FIG. **9**. FIGS. **11** and **12** schematically illustrate planar images of a structure of FIG. **10**B obtained using a fluorescence microscope.

[0080] Hereinafter, a method for observing and/or inspecting a shape of a photoresist pattern will be described with reference to FIGS. **9**, **10**A, **10**B, **11**, and **12**. The descriptions to the same technical features as in FIGS. **1**, **2**A, **2**B, and **3** will be omitted or briefly mentioned for the purposes of ease and convenience.

[0081] Referring to FIGS. **9** and **10**A, an etch target layer **210** may be formed on a substrate **200** (S**200**). The substrate **200** may be, including but not limited to, a semiconductor substrate, a glass substrate, and/or a polymer substrate. In example embodiments, when the substrate **200** is a semiconductor substrate, the substrate **200** may include at least one of, including but not limited to, crystalline silicon, amorphous silicon, silicon doped with dopants, or silicon-germanium.

[0082] The etch target layer **210** may include at least a semiconductor material, a conductive material, and/or an insulating material. In example embodiments where the etch target layer **210** includes the semiconductor material, the etch target layer **210** may be a portion of the semiconductor substrate **200**, an epitaxial layer formed of a semiconductor material, and/or a semiconductor layer deposited on the substrate **200**. In example embodiments where the etch target layer **210** includes the conductive material, the etch target layer **210** may include doped poly-silicon, a metal, a metal silicide, a metal nitride, or any combination thereof.

[0083] In example embodiments, when the etch target layer **210** includes the insulating material, the etch target layer **210** may include at least silicon oxide, silicon nitride, or silicon oxynitride. The etch target layer **210** may be a single layer and/or a multi-layer including a plurality of stacked layers. In example embodiments, the etch target layer **210** may include a plurality of stacked insulating layers and a conductive or semiconductor layer disposed between the stacked insulating layers. The etch target layer **210** may be formed using, for example, a CVD method, a PVD method, and/or an ALD method.

[0084] A fluorescent anti-reflective layer **220** may be formed on the etch target layer **210** (S**210**). The fluorescent anti-reflective layer **220** may limit (and/or prevent) uniformity of critical dimensions of photoresist patterns **232** of FIG. **10**B to be described later from being deteriorated by reflected light in a subsequent photolithography process. The fluorescent anti-reflective layer **220** may be formed by, for example, a spin coating process.

[0085] The fluorescent anti-reflective layer **220** may include a fluorescent additive. The fluorescent additive may include a material that inherently has the fluorescence or that can have the fluorescence by an exposure process, a development process, and/or a bake process. That is, for example, the fluorescent additive may include Cy5 or Alexa647. In example embodiments, the fluorescent anti-reflective layer **220** may include a plurality of fluorescent additives. In example embodiments, the plurality of fluorescent additives may have fluorescent colors different from each other. For example, the plurality of fluorescent additives may include a first fluorescent additive and a second fluorescent additive, which have fluorescent colors different from each other.

[0086] A photoresist layer **230** may be formed on the fluorescent anti-reflective layer **220**. In example embodiments, the photoresist layer **230** may not have fluorescence. In other words, the photoresist layer **230** may not have both a fluorescent additive and a fluorescent resin. Alternatively, in example embodiments, the photoresist layer **230** may have fluorescence. In example embodiments, a fluorescent color of the photoresist layer **230** may be different from that of the fluorescent anti-reflective layer **220**. In example embodiments, the photoresist layer **230** may include at least one of a fluorescent additive or a fluorescent resin. The fluorescent additive or the fluorescent resin may be the same as described with reference to FIGS. **1** and **2**A. Hereinafter, the photoresist layer **230** not having the fluorescence will be described as an example for the purposes of ease and convenience.